

**What is claimed is:**

1. A method for the electrochemical detection of an analyte molecule by means of a detection electrode, the method comprising:
  - 5 (a) immobilizing capture molecules, which are capable of binding the analyte molecule to be detected, on the detection electrode;
  - (b) contacting the electrode with a solution supposed to contain the analyte molecule to be detected;
  - (c) allowing the analyte molecule contained in said solution to bind to the capture molecules on the electrode, thereby allowing formation of complexes between a capture molecule and an analyte molecule, said complexes forming a first layer on the detection electrode;
  - 10 (d) contacting the detection electrode with an electrochemical activator, wherein said electrochemical activator has a electrostatic net charge that is complementary to the electrostatic net charge of the complex formed between a capture molecule and an analyte molecule, thereby forming a second layer on the electrode, wherein the second layer and the first layer together form a conducting bilayer;
  - 15 (e) contacting the detection electrode with an agent capable of transferring electrons to or from the electrochemical activator from or to the electrode, respectively;
  - (f) performing an electrical measurement at the detection electrode, and;
  - (g) detecting the analytes by comparing the result of the electrical measurement obtained with that of a control measurement.
- 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 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5230 5235 5240 5245 5250 5255 5260 5265 5270 5275 5280 5285 5290 5295 5300 5305 5310 5315 5320 5325 5330 5335 5340 5345 5350 5355 5360 5365 5370 5375 5380 5385 5390 5395 5400 5405 5410 5415 5420 5425 5430 5435 5440 5445 5450 5455 5460 5465 5470 5475 5480 5485 5490 5495 5500 5505 5510 5515 5520 5525 5530 5535 5540 5545 5550 5555 5560 5565 5570 5575 5580 5585 5590 5595 5600 5605 5610 5615 5620 5625 5630 5635 5640 5645 5650 5655 5660 5665 5670 5675 5680 5685 5690 5695 5700 5705 5710 5715 5720 5725 5730 5735 5740 5745 5750 5755 5760 5765 5770 5775 5780 5785 5790 5795 5800 5805 5810 5815 5820 5825 5830 5835 5840 5845 5850 5855 5860 5865 5870 5875 5880 5885 5890 5895 5900 5905 5910 5915 5920 5925 5930 5935 5940 5945 5950 5955 5960 5965 5970 5975 5980 5985 5990 5995 6000 6005 6010 6015 6020 6025 6030 6035 6040 6045 6050 6055 6060 6065 6070 6075 6080 6085 6090 6095 6100 6105 6110 6115 6120 6125 6130 6135 6140 6145 6150 6155 6160 6165 6170 6175 6180 6185 6190 6195 6200 6205 6210 6215 6220 6225 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4. The method of claim 3, wherein the metal ions are selected from the group consisting of silver, gold, copper, nickel, iron, cobalt, osmium, ruthenium, and mixtures thereof.
5. The method of claim 4, wherein the electrochemical activator is selected from the group consisting of poly(vinyl ferrocene), poly(vinyl ferrocene)-co-acrylamide, poly(vinyl ferrocene)-co-acrylic acid, and poly(vinyl ferrocene)-co-acrylamido-(CH<sub>2</sub>)<sub>n</sub>-sulfonic acid, and poly(vinyl ferrocene)-co-acrylamido-(CH<sub>2</sub>)<sub>n</sub>-phosphonic acid, wherein n = 0-12.  
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6. The method of claim 1, wherein the agent capable of transferring electrons to or from the electrochemical activator is an enzyme or an enzyme-conjugate.  
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7. The method of claim 6, wherein the enzyme is an oxidoreductase or a mixture of oxidoreductases.  
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8. The method of claim 7, wherein the oxidoreductase is selected from the group consisting of glucose oxidase, hydrogen peroxidase, lactate oxidase, alcohol dehydrogenase, hydroxybutyrate dehydrogenase, lactic dehydrogenase, glycerol dehydrogenase, sorbitol dehydrogenase, glucose dehydrogenase, malate dehydrogenase, galactose dehydrogenase, malate oxidase, galactose oxidase, xanthine dehydrogenase, alcohol oxidase, choline oxidase, xanthine oxidase, choline dehydrogenase, pyruvate dehydrogenase, pyruvate oxidase, oxalate oxidase, bilirubin oxidase, glutamate dehydrogenase, glutamate oxidase, amine oxidase, NADPH oxidase, urate oxidase, cytochrome C oxidase, and acetochol oxidase.  
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9. The method of claim 1, wherein the capture molecules are capable of specifically binding the analytes to be detected.  
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10. The method of claim 1, wherein the analyte to be detected is selected from the group consisting of nucleic acids, oligonucleotides, proteins, peptides, oligosaccharides, polysaccharides and complexes thereof.

5 11. The method of claim 10, wherein the analyte to be detected is a nucleic acid molecule.

12. The method of claim 11, wherein the nucleic acid molecule has a pre-defined sequence.

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13. The method of claim 12, wherein the nucleic acid molecule comprise at least one single-stranded region.

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14. The method of claim 13, wherein the capture molecule is at least one nucleic acid probe having a sequence complementary to a single-stranded region of the nucleic acid molecule to be detected.

15. The method of claim 10, wherein the analyte to be detected is a protein or a peptide.

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15. The method of claim 15, wherein the capture molecule is at least one ligand capable of binding proteins or peptides.

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16. The method of claim 1, wherein a blocking agent is immobilized on the electrode prior to contacting the electrode with the solution supposed to contain the analyte molecule.

17. A method for the electrochemical detection of an analyte molecule by means of a detection electrode, the method comprising:

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- (a) immobilizing capture molecules, which are capable of binding the analyte molecule to be detected, on the detection electrode;
- (b) contacting the electrode with a solution supposed to contain the analyte molecule to be detected;

- (c) allowing the analyte molecule contained in said solution to bind to the capture molecules on the electrode, thereby allowing formation of complexes between a capture molecule and an analyte molecule, said complexes forming a first layer on the detection electrode;
- 5 (d) contacting the detection electrode with an electrochemical activator, wherein said electrochemical activator has an electrostatic net charge that is complementary to the electrostatic net charge of the complex formed between a capture molecule and an analyte molecule, thereby forming a second layer on the electrode, wherein the second layer and the first layer together form a conducting bilayer, and wherein the capture molecules are capable of transferring electrons to or from the electrochemical activator from or to the electrode, respectively;
- 10 (e) performing an electrical measurement at the detection electrode, and;
- 15 (f) detecting the analytes by comparing the result of the electrical measurement obtained with that of a control measurement.

18. An electrode arrangement, comprising a detection electrode, suitable for carrying out an electrochemical detection of an analyte molecule as defined in claim 1, comprising:

- (a) a first layer on the detection electrode comprising complexes between a capture molecule, which is capable of binding the analyte molecule to be detected, and an analyte molecule; and
- 25 (b) a second layer comprising an electrochemical activator, wherein said electrochemical activator has an electrostatic net charge that is complementary to the electrostatic net charge of the complex formed between a capture molecule and an analyte molecule, wherein the second layer and the first layer together form a conducting bilayer.

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19. The electrode arrangement of claim 18, wherein the electrochemical activator is a polymeric redox mediator capable of transferring electrons between the analyte and the electrode.

20. The electrode arrangement of claim 19, wherein the agent for increasing conductivity of the analytes contains metal ions.

5 21. The electrode arrangement of claim 20, wherein the metal ions are selected from the group consisting of silver, gold, copper, nickel, iron, cobalt, osmium, ruthenium and mixtures thereof.

10 22. The electrode arrangement of claim 18, further comprising an agent capable of transferring electrons to or from the polymeric redox mediator from or to the electrode, respectively, wherein the agent is bound to, intercalated in or associated with the conducting bilayer

15 23. The electrode arrangement of claim 22, wherein the agent is an enzyme or an enzyme-conjugate.

24. Use of an electrode arrangement of claim 18 as biosensor.

20 25. A biosensor for the electrochemical detection of an analyte molecule, comprising:

(a) an detection electrode;  
(b) a first layer on the detection electrode comprising complexes between a capture molecule, which is capable of binding the analyte molecule to be detected, and an analyte molecule; and

25 (c) a second layer comprising an electrochemical activator, wherein said electrochemical activator has an electrostatic net charge that is complementary to the electrostatic net charge of the complex formed between a capture molecule and an analyte molecule, wherein the second layer and the first layer together form a conducting bilayer.

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26. A water soluble redox polymer, comprising:

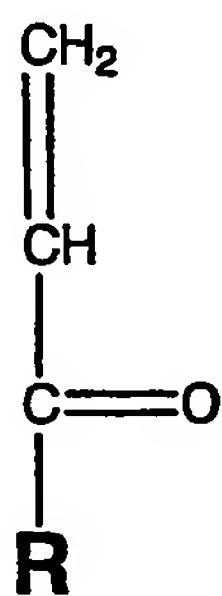
(a) a first monomer unit comprising a polymerizable ferrocene derivative; and

(b) a second monomer unit comprising an acrylic acid derivative having a primary acid or base functional group capable of acquiring a net charge.

5 27. The redox polymer of claim 26, wherein the second monomer unit comprises an acrylic acid derivative having an terminal primary acid or base functional group capable of acquiring a net charge.

10 28. The redox polymer of claim 26, wherein the acrylic acid derivative is represented by the general formula (I)

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wherein R is selected from the group consisting of C<sub>n</sub>H<sub>2n</sub>-NH<sub>2</sub>, C<sub>n</sub>H<sub>2n</sub>-COOH, NH-C<sub>n</sub>H<sub>2n</sub>-PO<sub>3</sub>H, and NH-C<sub>n</sub>H<sub>2n</sub>-SO<sub>3</sub>H, wherein the alkyl chain can be optionally substituted, and wherein n is an integer from 0 to 12.

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29. The redox polymer of claim 26, wherein the polymerizable ferrocene derivative is selected from the group consisting of vinyl-ferrocene, acetylene-ferrocene, styrene-ferrocene and ethylene oxide-ferrocene.

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30. The redox polymer of claim 29, wherein the ferrocene derivative is vinyl ferrocene.

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31. The redox polymer of claim 26, wherein the molecular weight of the redox polymer is between about 1000 and 5000 Daltons.

32. The redox polymer of claim 26, wherein the ferrocene loading in the redox polymer is between about 3% and 14%.

33. A process for preparing a water soluble, redox polymer, said process comprising:

5 polymerising a first monomer unit comprising a polymerizable ferrocene derivative with a second monomer unit comprising an acrylic acid derivative having an acid or base functional group capable of acquiring a net charge, wherein said polymerization is carried out in an aqueous alcoholic medium.

10 34. The process of claim 33, wherein the aqueous alcoholic medium comprises ethanol and water in a volumetric ratio of between 2:1 and 3:1.

35. The process of claim 33, wherein the polymerization is initiated by adding a free radical initiator.

15 36. The process of claim 35, wherein the free radical initiator is selected from the group consisting of ammonium persulfate, potassium persulphate and sodium persulfate.

20 37. The process of claim 35 wherein the weight ratio of free radical initiator added is between about 20 mg to 40 mg per 1 gram of monomer.

38. The process of claim 33, wherein polymerization is carried out under reflux at a temperature of between about 60 °C to 80 °C.

25 39. The process of claim 33, wherein polymerization is carried out in an inert gas atmosphere.

40. The process of claim 33, wherein polymerization is carried out for about 24 hours.

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41. The process according to claim 33, further comprising: forming a pre-reaction mixture prior to polymerizing said first and second monomers, comprising:

dissolving the acrylic acid derivative monomer unit in an aqueous alcoholic medium, then

adding the free radical initiator, and then

adding the polymerisable ferrocene derivative monomer unit to form the  
5 pre-reaction mixture.

42. The process of claim 41, wherein the feeding ratio of acrylic acid derivative to polymerizable ferrocene derivative in the pre-reaction mixture is between about 5% and 15% of the weight of monomer added.

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43. The process of claim 41, wherein the polymerizable ferrocene derivative monomer unit is dissolved in an aqueous alcoholic medium prior to being added.

15 44. The process of claim 41, further comprising precipitating the redox mediator in an organic solvent.

45. The process according to Claim 40, wherein the organic solvent is selected from the group consisting of an ether and ketone.

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